Patent Application

for

Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1)

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Background - Cross-References to Related Applications: N/A

Background - Field of Invention

This invention relates to the arts of liquid/liquid separators and vacuum transport systems, specifically to numerous significant improvements to a previously patented Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (US Pat 5,679,258 to Petersen dated 1997 October 21).

Background - Definitions

(a) The term "mixed" means two existing together.
(b) The term "immiscible" means naturally resisting, or being incapable of, blending or combining homogeneously and permanently. Immiscible liquids normally cannot be blended together whatsoever, or can be blended only slightly.
(c) The term "treated" means has already undergone some physical or chemical process or processes that has altered its original characteristics.
(d) The term "untreated" means has not yet undergone any physical or chemical process or processes intended to alter its original characteristics.
(e) The term "intermediate" means between two.
(f) The term "terminal" means the final, last, or end.
(g) The term "source" means the origination of, or the initial physical location of, untreated mixed immiscible liquids, and might comprise sumps, pits, tanks, bilges, drains, sewers, or spills into water or on land.

(h) The term "facility" means a physical point, site, location, treatment plant or system, sewer, drainage pipe, drainage field, or any container, tank, or similar storage receptacle.

(i) The term "phase" means an identifiable, partially or completely separable, component liquid in mixed immiscible liquids.

(j) The term "heavy phase" means the phase in mixed immiscible liquids with the higher specific gravity.

(k) The term "light phase" means the phase in mixed immiscible liquids with the lower specific gravity.

(l) The term "predominant phase" means the phase in mixed immiscible liquids that is greater than or equal to 50% by volume of the total volume of mixed immiscible liquids.

(m) The term "subdominant phase" means the phase in mixed immiscible liquids that is less than 50% by volume of the total volume of mixed immiscible liquids.

(n) The term "conduit" means a pipe, tube, hose, or other similar device to transport liquids or gases.

(o) The term "vacuum tank" means a sealed vessel, chamber, reservoir, or container capable of sustaining within itself a vacuum (negative atmospheric pressure) without structural collapse or leakage.

(p) The term "water" can mean distilled water, fresh water, lake water, stream water, river water, creek water, ground water, waste water, and/or sea water.

(q) The term "proximate" means physically adjacent to.

Background - Discussion of Prior Art

US Patent 5,679,258 to Petersen dated 1997 October 21 describes a system that:

1. Conveys, using negative atmospheric pressure (i.e., "vacuum collects"), two mixed immiscible liquids ("liquids") of different specific gravities from their source location(s) into a vacuum tank, and
2. Removes, under vacuum, any grit, sediment, particulates, and floating debris that might be present in the liquid inflow stream, and
3. Removes, under vacuum, any entrained air that might be present in the liquid inflow stream, and
4. Dissociates, under vacuum, the two liquids into their respective gross fractions inside the vacuum tank using:
    - 4.1. Vacuum-induced low grade dissolved air flotation, and
    - 4.2. Differential specific gravity/quiescent separation, and
    - 4.3. If the two liquids are water and oil, optional oleophilic media contact entrapment, and
5. Extracts the two separated phases from the vacuum tank and discharges them into:
    - 5.1. Supplemental phase separation stage(s), and/or
    - 5.2. Their respective phase terminal facilities.

The above described system suffers from a number of problems and disadvantages, more specifically described as follows (NOTE: The numbers in parentheses in the text refer to the "List of Reference Numerals" reflected in US Patent 5,679,258):

1 Emulsified oil (occasionally resembling pudding in consistency) that entered into the vacuum tank (51) could adhere to the phase interface sensor (44) - a float switch using a specially weighted float - which could immobilize it, thereby disabling its proper light phase (e.g., oil) extraction and discharge pump (39) and heavy phase (e.g., water) extraction and discharge

pump (38) operation selection function. As a consequence of this malfunction, oil could escape through the water extraction and discharge pump, or water could escape through the oil extraction and discharge pump. Also as noted in US Patent 5,679,258 "Background - Discussion of Prior Art" paragraph 10, electronic interface probes do not offer a preferential solution to this problem either. Thus, neither embodiment of the basic system affords reliable and consistent light phase/heavy phase (e.g., oil/water) interface detection.

2 The heavy phase (e.g., water) could inadvertently enter the light phase (e.g., oil) extraction and discharge pump inlet pipe elbow (26A) if, for example, the phase interface sensor failed (see paragraph (2) above), or if the oil extraction and discharge pump inlet piping check valve (52C) failed. Under these conditions, the oil extraction and discharge pump, at best, would eventually discharge the heavy phase (e.g., water) into the light phase receptacle(s) (41), thereby defeating the desire to minimize the quantity of water present with the separated and stored oil. In addition to the previous statement, and at worst, the oil extraction and discharge pump, despite being of a low sheer/low agitation type, would partially emulsify the oil, further complicating ultimate oil disposition.

3 Whenever the liquid surface level in the vacuum tank is at or just below the upper liquid surface level sensor (43C), then the liquid surface level in the narrow space between the floating light phase vertical barrier plate (37) and the grit, sediment, particulate, and floating debris removal/collection chamber wall (61) will rest nearly at the same level (depending of course on the amount of water and/or oil that is trapped in this narrow space). If the liquid is predominantly, or entirely, oil, then any water that enters the vacuum tank will flow over the horizontal overflow weir (62) and cascade down through this relatively thick layer of oil. This water flow will drag some of the oil with it under the bottom of the floating light phase vertical barrier plate, while agitating the remaining oil (even if slightly), which will emulsify it (even if slightly). Minimizing the degree of oil emulsification is generally desirable in all styles and types of oil/water separators.

4 The inflow stream grit, sediment, particulate, and floating debris chamber barrier screen (45), which provided about 75 in^2 of net effective surface area, would, unless the liquid inflow stream was unusually "clean", plug after only a few hours of system operation, thereby rendering further liquid collection and inflow impossible. To remedy this serious problem and restore full operational capabilities, the operator performed one (or both) of the following time-consuming actions:

A. Deenergized system electric power; purged vacuum tank vacuum; disconnected and temporarily removed selected system components that permitted subsequent access to vacuum tank interior; removed vacuum tank top; cleaned inflow stream grit, sediment, particulate, and floating debris chamber barrier screen; reinstalled vacuum tank top; reconnected system components previously removed; reenergized system electric power.

B. Deenergized system electric power; purged vacuum from tank vacuum; introduced water into vacuum tank through vacuum tank bottom drain valve (53B) until vacuum tank was almost completely full; opened grit, sediment, particulate, and floating debris removal/collection chamber drain valve (53C), which backflushed inflow grit, sediment, particulate, and floating debris chamber barrier screen, hopefully removing all or most of the accumulated material. If this tactic failed, then the operator resorted to restorative action A above.

Summary of the Invention - Objectives and Advantages

Accordingly, and together with US Patent 5,679,258 "Summary of the Invention - Objects and Advantages" numbers (5) - (9), (11), (13), and (14), which are repeated with revised identification numbers and some text revisions below, other objectives and advantages of this invention are:

(1) To preserve, and to enhance, gross light phase and heavy phase separation inside the vacuum tank, and once separated, to enable automatic light phase and heavy phase removal from the vacuum tank without needing or using any type (e.g., mechanical, electrical, electro-mechanical, electronic) of interface detector, sensor, device, or other means, by employing instead specially configured and designed baffling inside the vacuum tank that create a light phase only sump and a heavy phase only sump, each sump connecting to, respectively, the light phase (oil) extraction and discharge pump and the heavy phase (water) extraction and discharge pump, further with each sump being equipped with its own liquid surface level sensors, and with each sump incorporating its own inflow control horizontal weir, each weir existing at different elevations, the light phase sump inflow control horizontal weir being higher than the heavy phase sump inflow control horizontal weir. More succinctly, the invention described herein performs, as a minimum, exactly the same functions described in the Background - Discussion of Prior Art paragraph above without an interface sensor.

(2) To prevent inadvertent entry of the heavy phase (e.g., water) into the light phase (e.g., oil) extraction and discharge pump inlet by employing instead specially configured and designed baffling and respective light phase only and heavy phase only sumps inside the vacuum tank, which in turn, and respectively, connect to light phase (oil) and heavy phase (water) extraction and discharge pumps, in conjunction with instream flow rate control/limiting features/devices/means.

(3) To further reduce the degree of oil emulsification that might result when water descends through any floating oil layers inside the vacuum tank by reducing the height of the oil that the water must penetrate.

(4) To economically and efficiently intercept, trap, and/or remove with minimum liquid agitation or turbulence any grit, sediment, particulates, and/or floating debris that are entrained in the mixed immiscible liquids by inserting a standard prefilter/strainer element/cartridge that provides about 1530 in^2 of net effective surface area in the inflow stream piping before the vacuum tank, thereby:

   (a) Enhancing the degree/amount of grit, sediment, particulate, and/or floating debris removal, and

   (b) Dramatically extending the intervals between interception device cleaning and/or replacement due to the dramatically increased (by about 20x) net effective surface area, and

   (c) Providing a convenient and quick method of replacement/cleaning, thus restoring the system to operation much faster than before, and

   (d) Preventing any grit, sediment, particulates, and/or floating debris from interfering with the proper operation of the respective light phase and heavy phase sump free surface lower and upper liquid surface level sensors, and

   (e) Preventing any grit, sediment, and/or particulates from entering the respective light phase and heavy phase pump suction pipes.

(5) To preserve prevention of disturbance or agitation of the floating light phase inside the vacuum tank during mixed immiscible liquids collection (while preserving the air elimination and anti-back-siphonage features inherent in the prior art system) by introducing all mixed immiscible liquids collected onto a horizontal plate that is positioned slightly above the maximum probable

upper liquid surface level in the vacuum tank, and features a raised barrier plate at one end, which forces the liquids to the barrier free opposite end, where the liquids flow down through a narrow space that is formed by a vertical baffle and the end of the vacuum tank, with the vertical baffle extending below the probable light phase/heavy phase interface detection elevation, which deposits the liquids in a laminar flow, and with minimal agitation and no entrained air bubbles, well under any light phase floating in the vacuum tank.

(6) To preserve adequate time of detention of the two phases in the vacuum tank to permit gross fractions of the light phase to float to the surface.

(7) To preserve the option to install inside the vacuum tank oleophilic media offering a relatively high surface area when compared to its in-place volume, which further increases opportunities for entrapment or coalescence of the light phase when the light phase is oil in water inside the vacuum tank. This media should also be non-interconnecting and offer a low packing factor (that is, low pressure drop per unit of flow distance in the direction of flow).

(8) To preserve the simpler, more reliable, and less costly method to prevent liquid entry into the vacuum pump by using the already existing extraction and discharge pump automatic activation liquid surface level sensors to simultaneously de-energize the vacuum pump and the vacuum pump control circuits as long as it/they sense(s) a liquid presence. Furthermore, to add a liquid surface level activated relief valve to quickly purge the vacuum in the vacuum tank before any residual vacuum in the vacuum tank can draw liquid into the vacuum tank above the heavy phase sump inflow control horizontal weir, which could cause heavy phase to enter the light phase sump.

(9) To preserve the use and position of the vacuum relief valve so that it may perform the dual functions of providing a source of cooling air to the vacuum pump in case a malfunction causes it to run without its normal source of air from the vacuum tank, and ensuring the net positive suction head required by the light phase (oil) extraction and discharge pump and heavy phase (water) extraction and discharge pump does not exceed the net positive suction head available.

(10) To preserve activation of remote and/or local visual and/or audible alarms and automatically stop, or to prevent, operation of the vacuum pump, heavy phase extraction and discharge pump, or light phase extraction and discharge pump if the light phase storage receptacle(s) fill(s) to capacity by adding a liquid surface level sensor in the light phase storage receptacle(s) which will de-energize the vacuum pump, heavy phase pump, and light phase pump and their respective control circuits as long as the liquid surface level sensor senses a liquid presence.

(11) To preserve the incorporation of a check valve in the heavy phase discharge piping downstream of the heavy phase intermediate treatment stage.

(12) To preserve conveyance of exhaust air from the vacuum pump into the vent conduit of the light phase storage receptacle(s). This duct also serves as a conduit for any liquid which accidentally enters the vacuum pump, the liquid then filling the light phase storage receptacle(s). In conjunction with the liquid surface level sensing device mentioned in subparagraph (10) above, this combination will provide almost fail safe prevention against accidental light phase discharge into the environment caused by overfilling the light phase storage receptacle(s), either by the light phase pump, or by the vacuum pump.

(13) To preserve the accommodation of secondary separation of the light phase component once discharged from the vacuum tank in a similar manner as the heavy phase.

(14) To preserve the incorporation of a pressure differential sensor, or a flow sensor, that activates an alarm device that recommends coalescer element replacement if the element becomes plugged or fouled to the point that overall system through-put becomes unacceptable to the system owner or operator.

(15) To incorporate a liquid surface level sensor inside the prefilter vessel that activates an alarm device that activates an alarm device that recommends prefilter element replacement if the element becomes plugged or fouled to the point that overall system through-put becomes unacceptable to the system owner or operator.

(16) To preserve the accommodation, without adverse affect, the continuous or intermittent collection of mixed immiscible liquids of differing specific gravities in any mix, with or without grit, sediment, particulates, and/or floating debris, with or without entrained air, whether mechanically, electro-mechanically, or manually initiated and/or controlled, plus their separation into their respective phases, and plus their automatic discharge into their respective terminal facilities, either directly from the vacuum tank, or through an intermediate separation stage.

Further objects and advantages of this invention will become apparent from a consideration of the drawings and ensuing descriptions.

Description of the Drawings

FIG 1 outlines the basic process steps performed by the invention in flow chart form. This figure is not to scale.

FIG 2 shows major system components and general system flow patterns, and graphically depicts some of the many possible mixed immiscible liquids collection and separated phase discharge conduit options available. This figure is a partial schematic. This figure is not to scale.

FIG 3 is a total system schematic of the invention in single line form. While not to scale, it shows the relative positions of vacuum tank internal and connection details.

FIG 4 is a partial cross-sectional elevation through the top of the invention in its preferred embodiment with the prefilter vessel (or the coalescer vessel) oriented vertically above the vacuum tank that shows the recommended prefilter (or coalescer) vessel base articulation option to facilitate element replacement by using a standard hinge and chain or wire to limit vessel tilt. FIG 4 shows the vessel in its normal position and in its tilted position for element replacement. This figure is not to scale.

FIG 5 is a partial elevation of the front of the invention in its preferred embodiment with the prefilter vessel (or the coalescer vessel) oriented vertically above the vacuum tank that also shows the recommended prefilter (or coalescer) vessel base articulation option to facilitate element replacement by using a standard hinge. FIG 5 shows the vessel only in its normal position. This figure is not to scale.

FIG 6 and FIG 7 are both cross-sectional elevations of the vacuum tank only that show alternative configurations of the light phase sump, the heavy phase sump, and the heavy phase equalization chamber. This figure is not to scale.

FIG 8, FIG 9, FIG 10, FIG 11, FIG 12, FIG 13, FIG 14, and FIG 15 are all plan view schematics of the vacuum tank that show alternative configurations of the main gross phase separation chamber, the light phase sump, the heavy phase sump, and the heavy phase equalization chamber. This figure is not to scale

List of Reference Numerals

10	Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1)
20	Grit, particulates, and floating debris removal stage
30	Light phase intermediate separation stage
31	Light phase discharge conduit
32	Partially treated light phase conduit
33	Light phase intermediate separation stage heavy phase return conduit
40	Heavy phase intermediate separation stage
41	Heavy phase discharge conduit
42	Partially treated heavy phase conduit
43	Heavy phase intermediate separation stage light phase return conduit
50	Electrical/logic panel
100	Vacuum tank
110	Energy dissipation and flow distribution chamber
111	Energy dissipation and flow distribution chamber left end plate
112	Energy dissipation and flow distribution chamber right end plate
113	Energy dissipation and flow distribution chamber perforated bottom plate
114	Separated light phase protection roof
115	Separated light phase protection roof right end plate
116	Prefilter vessel outlet vacuum tank penetration
117	Coalescer vessel drain vacuum tank penetration
118	Coalescer vessel trickle return line vacuum tank penetration
120	Air void
130	Separated light phase anti-disturbance chamber
131	Separated light phase anti-disturbance baffle
132	Dynamic inflow level
140	Main gross phase separation chamber
141	Perforated oleophilic media containment plate
142	Oleophilic media containment bar
143	Oleophilic media
144	Light phase/heavy phase interface
145	Drain valve
145A	Drain conduit
150	Light phase sump
151	Light phase sump left plate
152	Light phase sump bottom plate
153	Light phase sump right plate
154	Light phase sump weir static level
155	Light phase sump weir dynamic level
156	Light phase sump lower liquid surface control level
156A	Light phase sump lower liquid surface level sensor
157	Light phase sump upper liquid surface control level
157A	Light phase sump upper liquid surface level sensor
158	Light phase sump liquid level sensor guide rod
159	Drain valve
159A	Drain conduit

160	Heavy phase equalization chamber
170	Heavy phase sump
171	Heavy phase sump left plate
172	Heavy phase sump weir static level
173	Heavy phase sump weir dynamic level
174	Heavy phase sump lower liquid surface control level
174A	Heavy phase sump lower liquid surface level sensor
175	Heavy phase sump middle liquid surface control level
175A	Heavy phase sump middle liquid surface level sensor
176	Heavy phase sump upper liquid surface control level
176A	Heavy phase sump upper liquid surface level sensor
177	Heavy phase sump liquid level sensor guide rod
178	Drain valve
178A	Drain conduit
200	Prefilter vessel
201	Removable prefilter vessel cover
202	Prefilter element
210	Prefilter vessel liquid surface control level
210A	Prefilter vessel liquid surface level sensor
230	Mixed immiscible liquids collection conduit
231	Prefilter vessel discharge conduit
232	Local collection conduit
240	Remote float or other mechanically actuated and controlled valve
241	Remote manually activated and controlled valve
242	Remote solenoid, motorized, or other electro-mechanically actuated and controlled valve
243	Collection network valve
244	Local collection valve
245	Prefilter vessel exit flow control valve
250	Vacuum/pressure gauge
300	Coalescer vessel
301	Removable coalescer vessel cover
302	Coalescer element
303	Flow rate limiting orifice
320	Differential pressure sensor
330	Drain conduit
340	Drain valve
341	Shut-off valve
342	Check valve
343	Metering valve
344	Self-closing quick disconnect
345	Siphon breaker
350	Vacuum/pressure gauge
400	Vacuum pump
420	Vacuum sensor
430	Vacuum pump inlet air conduit
431	Vacuum pump exhaust air conduit
432	Bi-directional air conduit

440	Self-closing check valve
441	Self-closing relief check valve
442	Solenoid relief valve
443	Vacuum regulating valve
450	Vacuum/pressure gauge
500	Light phase extraction and discharge pump
530	Light phase extraction and discharge pump suction conduit
540	Pressure relief valve
541	Check valve
542	Light phase extraction and discharge pump suction shut-off valve
543	Light phase extraction and discharge pump discharge shut-off valve
545	Siphon breaker
550	Vacuum/pressure gauge
600	Heavy phase extraction and discharge pump
630	Heavy phase extraction and discharge pump suction conduit
640	Pressure relief valve
641	Check valve
642	Heavy phase extraction and discharge pump suction shut-off valve
643	Heavy phase extraction and discharge pump discharge shut-off valve
650	Vacuum/pressure gauge
700	Light phase receptacle
720	Light phase receptacle liquid surface control level
720A	Light phase receptacle liquid surface level sensor
730	Air vent conduit
760	Air vent conduit cap

Description of the Invention

FIG 1 shows the basic process in flowchart form. More specifically, FIG 1 shows:

- An inflow stream, which typically contains mixed immiscible liquids, and might contain grit, sediment, particulates, floating debris, and/or air.
- A grit, sediment, particulates, and floating debris removal stage, followed by an air removal stage, followed by an initial phase separation stage, followed by temporary storage stages for partially or totally separated light and heavy phases, respectively.
- Optional intermediate separation stages for partially separated light and heavy phases, respectively.
- Optional stages that trap light phase at the heavy phase intermediate separation stage, and that trap heavy phase at the light phase intermediate separation stage.
- Terminal facilities for each respective separated phase.
- Circled question marks, which indicate a choice in flow paths.

FIG 2 shows some of the main components of a Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** in an embodiment that uses the optional intermediate phase separation stages mentioned in the paragraph above, together with the optional subdominant phase return lines exiting the intermediate predominant phase separation stages. One, or many, mixed immiscible liquids collection conduit(s) **230** connects to one or many mixed immiscible liquids sources through one or many, or any combination of, remote float or other mechanically actuated and controlled valve(s) **240**, remote manually actuated and controlled valve(s) **241**, and/or remote solenoid, motorized,

or other electrically actuated and controlled valve(s) **242** through a grit, sediment, particulates, and floating debris collection/removal stage **20** and into a vacuum tank **100**. As described further in the next paragraph below, grit, sediment, particulates, and floating debris collection/removal stage **20** is external to vacuum tank **100**. Vacuum tank **100** further connects to an optional light phase intermediate separation stage **30** (i.e., the light phase is the predominant phase) via a partially treated light phase conduit **32** and a light phase intermediate separation stage heavy phase return conduit **33**. Vacuum tank **100** further connects to an to an optional heavy phase intermediate separation stage **40** (i.e., the heavy phase is the predominant phase) via a partially treated heavy phase conduit **42** and a heavy phase intermediate separation stage light phase return conduit **43**. A light phase discharge conduit **31** carries separated light phase liquid to any one or several optional terminal facilities. Likewise, a heavy phase discharge conduit **41** carries separated heavy phase liquid to any one of several optional terminal facilities. A vacuum pump exhaust air conduit **431** carries air extracted from vacuum tank **100**.

FIG 3 shows many more details of the main Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**. FIG 3 shows interior details of vacuum tank **100**, as well as all the other components and features which contribute to Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** operational performance.

Vacuum tank **100** is a closed, horizontally oriented, cylinder that is structurally capable of withstanding a 28 inch Mercury vacuum without imploding, and without deforming appreciably from its resting, atmospheric pressure-equalized, non-vacuum, condition. Vacuum tank **100** may also be oriented vertically, however, adjustments to many of the features and details described below, which apply to a horizontally oriented vacuum tank, will be necessary if a vertical vacuum tank is employed.

Inside vacuum tank **100** is an energy dissipation and flow distribution chamber **110**, an air void **120**, a separated light phase anti-disturbance chamber **130**, a main gross phase separation chamber **140**, a light phase sump **150**, a heavy phase equalization chamber **160**, and a heavy phase sump **170**.

Energy dissipation and flow distribution chamber **110** is formed by the space enclosed by the curved interior upper surface of vacuum tank **100**, an energy dissipation and flow distribution chamber left end plate **111**, an energy dissipation and flow distribution chamber right end plate **112**, and an energy dissipation and flow distribution chamber perforated bottom plate **113**. Energy dissipation and flow distribution chamber left end plate **111** and energy dissipation and flow distribution chamber right end plate **112** are both relatively thin (say about 1/4") and semicircular in shape. Energy dissipation and flow distribution chamber left end plate **111** and energy dissipation and flow distribution chamber right end plate **112** both orient vertically and feature a horizontal bottom edge and a curved top edge that matches the inside curvature of vacuum tank **100**. Energy dissipation and flow distribution chamber perforated bottom plate **113** is relatively thin (say about 1/4") and rectangular in shape. Energy dissipation and flow distribution chamber perforated bottom plate **113** orients horizontally. Energy dissipation and flow distribution chamber left end plate **111**, energy dissipation and flow distribution chamber right end plate **112**, and energy dissipation and flow distribution chamber perforated bottom plate **113** all attach continuously along their respective side edges to vacuum tank **100**. The left edge of energy dissipation and flow distribution chamber perforated bottom plate **113** attaches continuously to the bottom edge of energy dissipation and flow distribution chamber left end plate **111**. The right edge of energy dissipation and flow distribution chamber perforated bottom plate **113** attaches continuously to the bottom edge of energy dissipation and flow distribution chamber right end plate **111**. The inside bottom surface of

energy dissipation and flow distribution chamber perforated bottom plate **113** lies about 3/4" below the crown of vacuum tank **100**. A prefilter vessel outlet vacuum tank penetration **116**, a coalescer vessel drain vacuum tank penetration **117**, and a coalescer vessel trickle return line vacuum tank penetration **118** all penetrate vacuum tank **100** into energy dissipation and flow distribution chamber **110**. Energy dissipation and flow distribution chamber perforated bottom plate **113** features 15 each 1/4" diameter holes that are spaced in a 3" X 2" on-center grid pattern of 3 columns of 5 holes and 5 rows of 3 holes. The total hole area in energy dissipation and flow distribution chamber perforated bottom plate **113** is about 1.5 times the net opening area of prefilter vessel outlet vacuum tank penetration **116**.

Directly below energy dissipation and flow distribution chamber **110** is a separated light phase protection roof **114**. Separated light phase protection roof **114** is relatively thin (say about 1/4") and rectangular in shape. The top surface of separated light phase protection roof **114** orients horizontally about 1.5" below the bottom surface of energy dissipation and flow distribution chamber perforated bottom plate **113** to allow instream flow air elimination rightward above leftward flowing liquid along the top surface of separated light phase protection roof **114**. A separated light phase protection roof right end plate **115** lies at the right end of separated light phase protection roof **114**. Separated light phase protection roof right end plate **115** is relatively thin (say about 1/4") and modified semi-circular in shape. Separated light phase protection roof right end plate **115** orients vertically and features horizontal top and bottom edges and curved left and right side edges that match the inside curvature of vacuum tank **100**. The top edge of separated light phase protection roof right end plate **115** lies about 1" below the crown of vacuum tank **100**, and about 3" to the right of energy dissipation and flow distribution chamber right end plate **112**. Separated light phase protection roof right end plate **115** prevents liquid that exits energy dissipation and flow distribution chamber **110** from flowing rightward and falling through and disturbing any resting separated light phase in main gross phase separation chamber **140**, while allowing the rightward flow of any entrained air. The side edges of separated light phase protection roof **114** attach continuously to vacuum tank **100**. The right end edge of separated light phase protection roof **114** attaches continuously to the bottom edge of separated light phase protection roof right end plate **115**. The side edges of separated light phase protection roof right end plate **115** attach continuously to vacuum tank **100**.

Separated light phase anti-disturbance chamber **130** lies at the left end of vacuum tank **100** and slightly below the bottom surface of separated light phase protection roof **114**. Separated light phase anti-disturbance chamber **130** is the space formed by the left end of vacuum tank **100**, a dynamic inflow level **132**, a separated light phase anti-disturbance baffle **131**, the leftward horizontal projection of the bottom edge of separated light phase anti-disturbance baffle **131**, and the curved interior surface of vacuum tank **100**. Separated light phase anti-disturbance baffle **131** is relatively thin (say about 1/4") and modified semi-circular in shape. Separated light phase anti-disturbance baffle **131** orients vertically and features horizontal top and bottom edges and curved left and right side edges that match the inside curvature of vacuum tank **100**. The side edges of separated light phase anti-disturbance baffle **131** attach continuously to vacuum tank **100**. The top edge of separated light phase anti-disturbance baffle **131** attaches continuously to the left edge of separated light phase protection roof **114**. The clear width (i.e., gap) between the left end of vacuum tank **100** and separated light phase anti-disturbance baffle **131** is about 1.5". The bottom edge of separated light phase anti-disturbance baffle **131** lies below a light phase/heavy phase interface **144**. Dynamic inflow level **132** establishes above a light phase sump weir dynamic level **155** when liquid flows into vacuum tank **100**.

Main gross phase separation chamber **140** is formed by space enclosed by the curved interior surface of vacuum tank **100**, the left end of vacuum tank **100**, a light phase sump left plate **151** and its downward vertical projection to the inside surface of vacuum tank **100**, and a light phase sump weir static level **154**, minus separated light phase anti-disturbance chamber **130**. The minimum volume of main gross phase separation chamber **140**, as measured in gallons, compared to the maximum design inflow rate, as measured in gallons per minute, should represent a ratio of about 10:1, together with maximum separation of the bottom of separated light phase anti-disturbance chamber **130** to the entrance of heavy phase equalization chamber **160**, which, in this combination, accommodates the desired detention time of a molecule of heavy phase liquid in main gross phase separation chamber **140** to about 10 minutes, assuming that plug flow conditions occur in main gross phase separation chamber **140**. The minimum horizontal clear distance (i.e., gap) between separated light phase anti-disturbance baffle **131** and light phase sump left plate **151** to ensure that discrete light phase that enters main gross phase separation chamber **140** from separated light phase anti-disturbance chamber **130**, and/or to ensure that light phase droplets that form and ascend in main gross phase separation chamber **140**, have sufficient time (about one (1) minute) to totally separate from the heavy phase in main gross phase separation chamber **140** and to join floating light phase in main gross phase separation chamber **140** without carrying heavy phase from main gross phase separation chamber **140** into a light phase sump **150** when light phase flows into light phase sump **150** can be estimated by the following formula:

$$G_{min} = (231 \times Q) / (D \times L)$$

Where: G_{min} = Gap, minimum, measured in inches

Q = Maximum design flow rate in a prefilter vessel exit conduit **231**, measured in gallons per minute

D = Depth of light phase, measured in inches (also the vertical distance between light phase sump weir static level **154** and light phase/heavy phase interface **144**)

L = Length of weir span (also length of top edge of light phase sump left plate **151**), measured in inches

An optional (recommended if the heavy phase is water or seawater, and if the light phase is an oil) perforated oleophilic media containment plate **141** lies inside main gross phase separation chamber **140**. Perforated oleophilic media containment plate **141** is relatively thin (say about 1/4") and rectangular in shape. The top surface of perforated oleophilic media containment plate **141** orients horizontally about 7.5" below separated light phase protection roof **114** and about 2" below light phase/heavy phase interface **144**. The holes in perforated oleophilic media containment plate **141** are slightly smaller than the smallest dimension of a quantity of oleophilic media **143**. Perforated oleophilic media containment plate **141** features holes in sufficient quantity so that liquid flow down, or up, in main gross phase separation chamber **140** occurs unimpeded, while maintaining adequate structural strength and rigidity to prevent oleophilic media **143** from floating above the horizontal plane established by perforated oleophilic media containment plate **141**. The sides of perforated oleophilic media containment plate **141** attach to vacuum tank **100**. The left edge of perforated oleophilic media containment plate **141** lies close to the left end of vacuum tank **100**, but no further than the smallest dimension of oleophilic media **143**. The right edge of perforated oleophilic media containment plate **141** lies close to light phase sump left plate **151**, but no further than the smallest dimension of oleophilic media **143**. An oleophilic media containment bar(s) **142** lie(s) directly below light phase sump left plate **151**. Oleophilic media

containment bar(s) **142** is/are sufficiently rigid to prevent oleophilic media **143** from entering heavy phase equalization chamber **160**, and is/are sized and spaced to minimize heavy phase flow head loss from main gross phase separation chamber **140** into heavy phase equalization chamber **160**. A quantity of oleophilic media **143** fills the space in main gross phase separation chamber **140** below perforated oleophilic media containment plate **141**. The ratio of oleophilic media **143**, measured in cubic feet, to the throughput of Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**, measured in gallons per minute, should be no less than 0.6:1. A drain valve **145** connects to a drain conduit **145A**, which penetrates and attaches to, the bottom of main gross phase separation chamber **140**.

Light phase sump **150** lies immediately to the right of main gross phase separation chamber **140**. Light phase sump **150** is formed by the curved interior surface of vacuum tank **100**, light phase sump left plate **151**, a light phase sump bottom plate **152**, a light phase sump right plate **153**, and the rightward horizontal projection of the top edge of light phase sump left plate **151** to its intersection with light phase sump right plate **153**. Light phase sump left plate **151**, light phase sump right plate **153**, and light phase sump right plate **153** are all relatively thin (say about 1/4"). Light phase sump left plate **151** and light phase sump right plate **153** both orient vertically and both are modified semi-circular in shape. Light phase sump right plate **153** is taller than light phase sump left plate **151**. Light phase sump left plate **151** and light phase sump right plate **153** both feature horizontal top and bottom edges and curved left and right side edges that match the inside curvature of vacuum tank **100**. Light phase sump bottom plate **152** orients horizontally and is rectangular in shape. The top edge of light phase sump left plate **151** establishes and corresponds to light phase sump weir static level **154**. The top edge of light phase sump left plate **151** lies about 3-1/4" below the crown of vacuum tank **100**. Light phase sump weir dynamic level **155** establishes horizontally above, or at, light phase sump weir static level **154** when liquid flows into vacuum tank **100**. The curved side edges of both light phase sump left plate **151** and light phase sump right plate **153** attach continuously to vacuum tank **100**, and to the left end edge and right end edge of light phase sump bottom plate **152**, respectively. The sides of light phase sump bottom plate **152** attach continuously to vacuum tank **100**. The bottom surface of light phase sump bottom plate **152** is about 2-1/4" above the invert of vacuum tank **100**. The horizontal clear distance between light phase sump left plate **151** and light phase sump right plate **153** is about 6-3/4". A light phase sump lower liquid surface control level **156** is established inside light phase sump **150** about 2-1/4" above the top surface of light phase sump bottom plate **152**. A light phase sump upper liquid surface control level **157** is established inside light phase sump **150** about 10" above light phase sump lower liquid surface control level **156**, and about 4-3/4" below light phase sump weir static level **154**. A light phase sump lower liquid surface level sensor **156A**, which slides vertically along a light phase sump liquid level sensor guide rod **158** between two limit stops, which restrict the vertical movement of light phase sump lower liquid surface level sensor **156A**, controls light phase sump lower liquid surface control level **156**. A light phase sump upper liquid surface level sensor **157A**, which slides vertically along light phase sump liquid level sensor guide rod **158** between two limit stops, which restrict the vertical movement of a light phase sump upper liquid surface level sensor **157A**, controls light phase sump upper liquid surface control level **157**. Light phase sump lower liquid surface level sensor **156A** and light phase sump upper liquid surface level sensor **157A** are both selected to float when only partially immersed in the light phase. The volume represented by the space between light phase sump lower liquid surface control level **156** and light phase sump upper liquid surface control level **157** inside light phase sump **150** should preclude short-cycling (e.g., more than one on-off cycle per minute) of a light phase extraction and discharge pump **500**. The top edge of light phase sump right plate **153** lies about 1-1/14" above light phase sump weir static

level **154** and about 2" below the crown of vacuum tank **100**. Light phase sump **150** is liquid tight. A drain valve **159** connects to a drain conduit **159A**, which penetrates through the wall of vacuum tank **100** and passes through the lower section of heavy phase equalization chamber **160** and penetrates and attaches to light phase sump bottom plate **152**.

Heavy phase equalization chamber **160** lies under, and to the right of, light phase sump **150**. Heavy phase equalization chamber **160** is formed by the curved interior surface of vacuum tank **100**, light phase sump bottom plate **152**, the downward vertical projection of light phase sump left plate **151** to the inside surface of vacuum tank **100**, a heavy phase sump left plate **171**, and the leftward horizontal projection of the top edge of heavy phase sump left plate **171** to its intersection with the vertical surface of light phase sump right plate **153**. The top edge of heavy phase sump left plate **171** establishes and corresponds to a heavy phase sump weir static level **172**. A heavy phase sump weir dynamic level **173** establishes horizontally above, or at, heavy phase sump weir static level **172** when liquid flows into vacuum tank **100**.

Heavy phase sump **170** lies immediately to the right of heavy phase equalization chamber **160**. Heavy phase sump **170** is formed by the curved interior surface of vacuum tank **100**, heavy phase sump left plate **171**, the right end of vacuum tank **100**, and the rightward horizontal projection of the top edge of heavy phase sump left plate **171** to its intersection with the right end of vacuum tank **100**. Heavy phase sump left plate **171** is relatively thin (say about 1/4") and is semi-circular in shape. Heavy phase sump left plate **171** orients vertically and features a horizontal top edge and a curved side edge that matches the inside curvature of vacuum tank **100**. The top edge of heavy phase sump left plate **171** establishes and corresponds to heavy phase sump weir static level **172**. The curved side edge of heavy phase sump left plate **171** attaches continuously to vacuum tank **100**. The horizontal clear distance between heavy phase sump left plate **171** and the right end of vacuum tank **100** is about 8". A heavy phase sump lower liquid surface control level **174** is established inside heavy phase sump **170** about 2-3/4" above the bottom of heavy phase sump **170**. A heavy phase sump middle liquid surface control level **175** is established inside heavy phase sump **170** about 10-1/4" above heavy phase sump lower liquid surface control level **174**. A heavy phase sump upper liquid surface control level **176** is established inside heavy phase sump **170** about 3" above heavy phase sump middle liquid surface control level **175**, and about 3-1/4" below heavy phase sump weir static level **172**. A heavy phase sump lower liquid surface level sensor **174A**, which slides vertically along a heavy phase sump liquid level sensor guide rod **177** between two limit stops, which restrict the vertical movement of heavy phase sump lower liquid surface level sensor **174A**, controls heavy phase sump lower liquid surface control level **174**. A heavy phase sump middle liquid surface level sensor **175A**, which slides vertically along light phase sump liquid level sensor guide rod **177** between two limit stops, which restrict the vertical movement of heavy phase sump middle liquid surface level sensor **175A**, controls heavy phase sump middle liquid surface control level **175**. A heavy phase sump upper liquid surface level sensor **176A**, which slides vertically along light phase sump liquid level sensor guide rod **177** between two limit stops, which restrict the vertical movement of heavy phase sump upper liquid surface level sensor **176A**, controls heavy phase sump upper liquid surface control level **176**. Heavy phase sump lower liquid surface level sensor **174A**, heavy phase sump middle liquid surface level sensor **175A**, and heavy phase sump upper liquid surface level sensor **176A** are all selected to float when only partially immersed in the heavy phase. The volume represented by the space between heavy phase sump lower liquid surface control level **174** and heavy phase sump middle liquid surface control level **175** inside heavy phase sump **170** should preclude short-cycling (e.g., more than one on-off cycle per minute) of a heavy phase extraction and discharge pump

600. Heavy phase sump upper liquid surface control level **176**, in combination with the air flow rating of a solenoid relief valve **442** that purges the negative pressure from vacuum tank **100**, should be sufficiently below heavy phase sump weir static level **172** to preclude inadvertent entry of any heavy phase liquid over the top edge of light phase sump left plate **151** into light phase sump **150**, which might occur if the liquid surface level in heavy phase sump **170** rises above the top edge of heavy phase sump left plate **171**. The top edge of heavy phase sump left plate **171** lies about 0.5" below the top edge of light phase sump left plate **151** and about 3-3/4" below the crown of vacuum tank **100**. Heavy phase sump **170** is liquid tight. The volume in heavy phase sump **170** between heavy phase sump lower liquid surface control level **174** and the rightward horizontal extension of heavy phase sump weir static level **172** should be greater than the volume of a coalescer vessel **300**. A drain valve **178** connects to a drain conduit **178A**, which penetrates and attaches to the bottom of heavy phase sump **170**.

To ensure the proper operation of Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**, the top surface of separated light phase protection roof **114** must lie above dynamic inflow level **132**, and light phase sump weir static level **154** must lie above heavy phase sump weir dynamic level **173**. Establishing these levels depends on three criteria:

1. The maximum inflow rate into vacuum tank **100** through prefilter vessel exit conduit **231**, and
2. The top edge span lengths of separated light phase anti-disturbance baffle **131** (which is also the left end span length of separated light phase protection roof **114**), light phase sump left plate **151**, and heavy phase sump left plate **171**, which all act as overflow weirs into separated light phase anti-disturbance chamber **130**, light phase sump **150**, and heavy phase sump **170**, respectively, and
3. Manufacturing tolerances to establish horizontal top edges on separated light phase anti-disturbance baffle **131**, light phase sump left plate **151**, and heavy phase sump left plate **171**.

The following formula will derive approximate heavy phase sump weir dynamic level **173** above heavy phase sump weir static level **172** for a given top edge span length of heavy phase sump left plate **171**, and approximate light phase sump weir dynamic level **155** above light phase sump weir static level **154** for a given top edge span length of light phase sump left plate **151**, respectively:

$$H = (12) \times [\,(Q) / (124.5) \times (L)\,]^{2/3}$$

Where: H = Dynamic level above the weir, measured in inches

Q = Flow rate in prefilter vessel exit conduit **231**, measured in gallons per minute

L = Length of weir span (same as the length of the top edge of the respective sump left plate), measured in inches

As discussed above, the bottom edge of separated light phase anti-disturbance baffle **131** must lie below light phase/heavy phase interface **144** to preclude disturbance of any floating light phase that lies rightward of separated light phase anti-disturbance baffle **131**. Once light phase sump weir static level **154** and heavy phase sump weir static level **172** are established, the vertical distance from light phase sump weir static level **154** to light phase/heavy phase interface **144** will derive based on the specific gravities of the light phase liquid and heavy phase liquid using the following formula:

$$D_{LP} = [(W_{LP,\ STATIC}) - (W_{HP,\ STATIC})] / [1 - (SG_{LP} / SG_{HP})]$$

Where: D_{LP} = Depth of floating light phase, measured in inches, between light phase sump weir static level **154** and light phase/heavy phase interface **144**

$W_{LP,\ STATIC}$ = Weir elevation, light phase, static, measured in inches, also light phase sump weir static level **154**

$W_{HP,\ STATIC}$ = Weir elevation, heavy phase, static, measured in inches, also heavy phase sump weir static level **172**

SG_{LP} = Specific Gravity, light phase

SG_{HP} = Specific Gravity, heavy phase

The bottom edge of separated light phase anti-disturbance baffle **131** should be about 1/4" lower than light phase/heavy phase interface **144**.

Air void **120** is all space inside vacuum tank **100** that is not otherwise delimited as energy dissipation and flow distribution chamber **110**, separated light phase anti-disturbance chamber **130**, main gross phase separation chamber **140**, light phase sump **150**, heavy phase equalization chamber **160**, or heavy phase sump **170**.

A prefilter vessel **200** provides the functions of grit, particulates, and floating debris removal stage **20**. Prefilter vessel exit conduit **231** connects the bottom of prefilter vessel **200** to energy dissipation and flow distribution chamber **110**. One, or many, mixed immiscible liquids collection conduit(s) **230** connect(s) prefilter vessel **200** to a remote, float or other mechanically actuated and controlled valve(s) **240**, to a remote manually activated and controlled valve(s) **241**, and/or to a remote, solenoid, motorized, or other electro-mechanically actuated and controlled valve(s) **242**. Mixed immiscible liquids collection conduit(s) **230** cross-sectional area(s) is/are sized to accommodate a design Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** inflow rate no more than about 2 ft/sec to minimize liquid inflow stream turbulence and agitation. A local collection conduit **232** connects to prefilter vessel **200**. A prefilter vessel exit flow control valve **245** inserts and installs into prefilter vessel exit conduit **231** between prefilter vessel **200** and energy dissipation and flow distribution chamber **110**. A collection network valve **243** inserts and installs into mixed immiscible liquids collection conduit **230** between prefilter vessel prefilter vessel and remote, float or other mechanically actuated and controlled valve(s) **240**, remote manually activated and controlled valve(s) **241**, and/or remote, solenoid, motorized, or other electro-mechanically actuated and controlled valve(s) **242**. A local collection valve **244** inserts and installs into local collection conduit **232**. Local collection valve **244** is sized to limit the maximum collection flow rate through local collection conduit **232** to the maximum design inflow rate of Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**. Prefilter vessel **200** features a prefilter element **202** and a removable prefilter vessel cover **201**. Prefilter element **202** mounts to the bottom of prefilter vessel **200** and is replaceable. Prefilter element **202** is a standard filter cartridge element or strainer preferably featuring passages no larger than 1 mm. A vacuum/pressure gauge **250** connects to prefilter vessel **200**. A prefilter vessel high liquid surface control level **210** is established inside prefilter vessel **200** near the top of prefilter element **202**. A prefilter vessel high liquid surface level sensor **210A** controls prefilter vessel high liquid surface control level **210**. Both mixed immiscible liquids collection conduit **230** and local collection conduit **232** connect to prefilter vessel **200** above prefilter vessel high liquid surface control level **210**. If prefilter vessel **200** mounts on top of vacuum tank **100** in its preferred vertical orientation as shown, then the bottom front of

prefilter vessel **200** can be articulated to its mounting (e.g., by a hinge, not shown) together with a tilt restraining device (e.g., by a chain, also not shown) to enable operators to tilt prefilter vessel **200** towards them to facilitate prefilter element **202** replacement.

Coalescer vessel **300** provides the functions of heavy phase intermediate separation stage **40**. A drain conduit **330** connects the bottom of coalescer vessel **300** to energy dissipation and flow distribution chamber **110**. Heavy phase discharge conduit **41** connects the heavy phase terminal facility to the bottom of coalescer vessel **300**. Partially treated heavy phase conduit **42** connects light phase extraction and discharge pump **500** to coalescer vessel **300**. Heavy phase intermediate separation stage light phase return conduit **43** connects the top of coalescer vessel **300** to energy dissipation and flow distribution chamber **110**. A check valve **342**, a shut-off valve **341**, and a siphon breaker **345** all insert and install into heavy phase discharge conduit **41** between coalescer vessel **300** and the heavy phase terminal facility. Siphon breaker **345** lies downstream of check valve **342**. A drain valve **340** inserts and installs into drain conduit **330** between coalescer vessel **300** and to energy dissipation and flow distribution chamber **110**. Drain valve **340** is sized to limit the maximum drainage flow rate through drain conduit **330** to the maximum design inflow rate of Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**. Alternatively, a flow rate limiting orifice **303** that inserts directly into drain conduit **330**, or that inserts at the connection of drain conduit **330** to coalescer vessel **300**, or that inserts at the connection of drain conduit **330** to energy dissipation and flow distribution chamber **110**, that also limits the maximum drainage flow rate through drain conduit **330** to the maximum design inflow rate of Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**, will nullify the aforementioned drain valve **340** sizing requirement. A metering valve **343** and a self-closing quick disconnect **344** insert and install into heavy phase intermediate separation stage light phase return conduit **43** between coalescer vessel **300** and energy dissipation and flow distribution chamber **110**. Coalescer vessel **300** features a coalescer element **302** and a removable coalescer vessel cover **301**. Coalescer element **302** mounts to the bottom of coalescer vessel cover **301** and is replaceable. A vacuum/pressure gauge **350** connects to coalescer vessel **300**. A differential pressure sensor **320** connects between coalescer vessel **300** and partially treated heavy phase conduit **42** upstream of a heavy phase extraction and discharge pump discharge shut-off valve **643**. Siphon breaker **345** lies above the top of coalescer vessel **300** to ensure that coalescer vessel **300** remains full during Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** operation, which will ensure the desirable purging of any light phase that separates in coalescer vessel **300** through heavy phase intermediate separation stage light phase return conduit **43**. If coalescer vessel **300** mounts on top of vacuum tank **100** in its preferred vertical orientation as shown, then the bottom front of coalescer vessel **300** can be articulated to its mounting (e.g., by a hinge, not shown) together with a tilt restraining device (e.g., by a chain, also not shown) to enable operators to tilt coalescer vessel **300** towards them to facilitate coalescer element **302** replacement.

The inlet of a vacuum pump **400** connects through a vacuum pump inlet air conduit **430** to the top of air void **120** at a point that is well above light phase sump weir static level **154** and that is well rightward of separated light phase protection roof right end plate **115**. The exhaust of vacuum pump **400** connects through vacuum pump exhaust air conduit **431** to an air vent conduit **730**, which connects to a light phase receptacle **700** and to an air vent conduit cap **760**. A bi-directional air conduit **432** connects vacuum pump exhaust air conduit **431** to the top of air void **120**. Bi-directional air conduit **432** penetrates and connects air void **120** at a point that is well above light phase sump weir static level **154** and that is well rightward of separated light phase protection roof right end plate **115**. A self-closing

check valve **440** inserts and installs in vacuum pump inlet air conduit **430** between vacuum pump **400** and air void **120**. Self-closing check valve **440** allows air flow in one direction from air void **120** to vacuum pump **400**. A self-closing relief check valve **441** inserts and installs in bi-directional air conduit **432** between air void **120** and the connection of vacuum pump exhaust air conduit **431** to bi-directional air conduit **432**. Self-closing relief check valve **441** may, alternatively, also connect, into vacuum pump exhaust air conduit **431** downstream of vacuum pump **400** and into vacuum pump inlet air conduit **430** upstream of self-closing check valve **440**. In this alternative configuration self-closing relief check valve **441** is effectively in parallel with self-closing check valve **440** and vacuum pump **400**. Self-closing relief check valve **441** allows air flow in one direction from air void **120** to vacuum pump exhaust air conduit **431**. The cracking pressure of self-closing relief check valve **441** is relatively low, say less than 0.5 pounds per square inch gauge.

A vacuum sensor **420**, solenoid relief valve **442**, a vacuum regulating valve **443**, and a vacuum/pressure gauge **450** all connect, directly and/or indirectly, to vacuum tank **100** using a variety of methods and configurations. Vacuum sensor **420**, solenoid relief valve **442**, vacuum regulating valve **443**, and vacuum/pressure gauge **450** may all be mounted in a variety of positions. Preferably, neither vacuum sensor **420**, solenoid relief valve **442**, vacuum regulating valve **443**, nor vacuum/pressure gauge **450** should connect to vacuum tank **100** so that any liquid can contaminate their respective internal parts.

The inlet of light phase extraction and discharge pump **500** connects through a light phase extraction and discharge pump suction conduit **530** into light phase sump **150**. Light phase extraction and discharge pump suction conduit **530** terminates at its lower end about 1" below light phase sump lower liquid surface control level **156**. A light phase extraction and discharge pump suction shut-off valve **542** and a check valve **541** insert and install into light phase extraction and discharge pump suction conduit **530** upstream of light phase extraction and discharge pump **500**. The outlet of light phase extraction and discharge pump **500** connects through partially treated light phase conduit **32** to light phase receptacle **700**. A siphon breaker **545** inserts and installs in partially treated light phase conduit **32** between light phase extraction and discharge pump **500** and light phase receptacle **700**. A light phase extraction and discharge pump discharge shut-off valve **543** inserts and installs in partially treated light phase conduit **32** between siphon breaker **545** and light phase extraction and discharge pump **500**. A pressure relief valve **540** inserts and installs into light phase extraction and discharge pump suction conduit **530** downstream of check valve **541** and into partially treated light phase conduit **32** upstream of light phase extraction and discharge pump discharge shut-off valve **543**. A vacuum/pressure gauge **550** connects to partially treated light phase conduit **32** upstream of light phase extraction and discharge pump discharge shut-off valve **543**.

The inlet of heavy phase extraction and discharge pump **600** connects through a heavy phase extraction and discharge pump suction conduit **630** into heavy phase sump **170**. Heavy phase extraction and discharge pump suction conduit **630** terminates at its lower end about 1" below heavy phase sump lower liquid surface control level **174**. A heavy phase extraction and discharge pump suction shut-off valve **642** and a check valve **641** insert and install into heavy phase extraction and discharge pump suction conduit **630** upstream of heavy phase extraction and discharge pump **600**. The outlet of heavy phase extraction and discharge pump **600** connects through partially treated heavy phase conduit **42** to coalescer vessel **300**. Heavy phase extraction and discharge pump discharge shut-off valve **643** inserts and installs in partially treated heavy phase conduit **42** between coalescer vessel **300** and heavy phase extraction and discharge pump **600**. A pressure relief valve **640** inserts and installs into heavy phase

extraction and discharge pump suction conduit **630** downstream of check valve **641** and into partially treated heavy phase conduit **42** upstream of heavy phase extraction and discharge pump discharge shut-off valve **643**. A vacuum/pressure gauge **650** connects to partially treated heavy phase conduit **42** upstream of heavy phase extraction and discharge pump discharge shut-off valve **643**.

Light phase receptacle **700** serves as the light phase terminal facility. A light phase receptacle liquid surface control level **720** is established inside light phase receptacle **700** near the top of light phase receptacle **700**. A light phase receptacle liquid surface level sensor **720A** controls light phase receptacle liquid surface control level **720**. Light phase receptacle liquid surface level sensor **720A** is selected to float when only partially immersed in the light phase.

Light phase receptacle liquid surface level sensor **720A**, prefilter vessel high liquid surface level sensor **210A**, differential pressure sensor **320**, solenoid relief valve **442**, vacuum sensor **420**, vacuum pump **400**, light phase extraction and discharge pump **500**, heavy phase extraction and discharge pump **600**, light phase sump lower liquid surface level sensor **156A**, light phase sump upper liquid surface level sensor **157A**, heavy phase sump lower liquid surface level sensor **174A**, heavy phase sump middle liquid surface level sensor **175A**, and heavy phase sump upper liquid surface level sensor **176A** all connect electrically to an electrical/logic panel **50**.

FIG 4 shows the above mentioned/recommended prefilter vessel **200**, and/or coalescer vessel **300**, base articulation option that facilitates element replacement by using a standard hinge and a chain (or wire) restraint that limits vessel tilt. The hinge top plate attaches at the front edge of the base of prefilter vessel **200** or coalescer vessel **300**. The hinge bottom plate attaches to the front edge of the vessel mounting bracket. This figure is not to scale.

FIG 5 is FIG 4 rotated counterclockwise 90 degrees about its vertical axis. This figure is not to scale.

FIG 6 and FIG 7 both show vacuum tank **100** (only) in an alternative configuration for light phase sump **150,** heavy phase equalization chamber **160**, and heavy phase sump **170**. Most of the details from FIG 3 are repeated, but some are intentionally omitted for clarity. These figures are not to scale.

FIG 8 through FIG 15 all show vacuum tank **100**, main gross phase separation chamber **140**, light phase sump **150,** heavy phase equalization chamber **160**, and heavy phase sump **170** in several different possible relational configuration cross-sectional plan schematics through vacuum tank **100** that will perform the primary phase separation and local storage functions mentioned above. Note that light phase sump **150** must always adjoin, at least partially, main gross phase separation chamber **140**, heavy phase sump **170** must always adjoin, at least partially, heavy phase equalization chamber **160**, and heavy phase equalization chamber **160** must always connect to main gross phase separation chamber **140**. These figures are not to scale.

Operation of the Invention

Referring to FIG 1, upon initial entry into Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**, any grit, sediment, particulates, and floating debris contained in the inflow stream are first eliminated from the inflow stream. Next, any entrained air in the inflow stream is eliminated from the inflow stream. Mixed immiscible liquids then flow to an initial phase separation

stage, whereupon each respective partially or totally separated phase is then temporarily stored. From temporary storage, each respective partially or totally separated phase then flows to either a(n) optional intermediate separation stage(s) or to its respective terminal facility. If a(n) optional intermediate separation stage(s) is/are used, then the predominant phase exiting the intermediate separation stage(s) may either flow to its respective terminal facility or return to temporary storage, joining its respective phase. If a(n) optional intermediate separation stage(s) is/are used, then the subdominant phase flowing from that particular intermediate separation stage can either flow to its respective predominant intermediate separation stage or to its terminal facility, can return to temporary storage, joining its respective phase, or can be locally trapped at the intermediate separation stage. The inflow stream into Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** can be continuous or intermittent with absolutely no adverse affect on Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** performance

Referring to FIG 2, vacuum tank **100** is under a constant, automatically regulated vacuum. The air from vacuum tank **100** exhausts through vacuum pump exhaust air conduit **431**. Mixed immiscible liquids from their respective sources will flow in mixed immiscible liquids collection conduit(s) **230** towards vacuum tank **100** when any combination or number of remote manually activated and controlled valve(s) **241**, remote float or other mechanically actuated and controlled valve(s) **240**, or remote solenoid, motorized, or other electro-mechanically actuated and controlled valve(s) **242** open(s). Mixed immiscible liquids flow will continue as long as any remote manually activated and controlled valve(s) **241**, remote float or other mechanically actuated and controlled valve(s) **240**, or remote solenoid, motorized, or other electro-mechanically actuated and controlled valve(s) **242** remain(s) open. Mixed immiscible liquids, once inside mixed immiscible liquids collection conduit(s) **230**, proceeds to grit, particulates, and floating debris removal stage **20**, where grit, sediment, particulates, and/or floating debris is removed from the mixed immiscible liquids inflow stream. Mixed immiscible liquids flow then continues from grit, particulates, and floating debris removal stage **20** in prefilter vessel exit conduit **231** into vacuum tank **100**, where any air entrained in the mixed immiscible liquids inflow stream is removed from the mixed immiscible liquids inflow stream. Initial phase separation of the mixed immiscible liquids also occurs in vacuum tank **100** through inherent immiscibility and specific gravity differences of the mixed immiscible liquids when resting in a relatively static, quiescent, temporary storage condition. In addition, low grade dissolved air flotation induced by the constant vacuum in vacuum tank **100** enhances initial gravity separation.

The partially separated heavy phase from vacuum tank **100** flows to heavy phase intermediate separation stage **40** through partially treated heavy phase conduit **42**. Light phase liquids separated by heavy phase intermediate separation stage **40** return to vacuum tank **100** through heavy phase intermediate separation stage light phase return conduit **43**, joining any pre-existent separated light phases at the top of vacuum tank **100**. Heavy phases further separated by heavy phase intermediate separation stage **40** flow through heavy phase discharge conduit **41** to its respective terminal facility(s).

The partially separated light phase from vacuum tank **100** flows to light phase intermediate separation stage **30** through partially treated light phase conduit **32**. Heavy phase liquids separated by light phase intermediate separation stage **30** return to vacuum tank **100** through light phase intermediate separation stage heavy phase return conduit **33**, joining any pre-existent separated heavy phases at the bottom of vacuum tank **100**. Light phases further separated by light phase intermediate separation stage **30** flow through light phase discharge conduit **31** to its respective terminal facility(s).

Referring to FIG 3, electrical/logic panel **50** is energized. The control switches (not shown) for vacuum pump **400**, light phase extraction and discharge pump **500**, and heavy phase extraction and discharge pump **600** are all in the "automatic" position.

The following valves are normally open: collection network valve **243**, prefilter vessel exit flow control valve **245**, shut-off valve **341**, metering valve **343**, light phase extraction and discharge pump suction shut-off valve **542**, light phase extraction and discharge pump discharge shut-off valve **543**, heavy phase extraction and discharge pump suction shut-off valve **642**, and heavy phase extraction and discharge pump discharge shut-off valve **643**.

The following valves are normally closed: drain valve **145**, drain valve **159**, drain valve **178**, remote float or other mechanically actuated and controlled valve **240**, remote manually activated and controlled valve **241**, remote solenoid, motorized, or other electro-mechanically actuated and controlled valve **242**, local collection valve **244**, and drain valve **340**.

Heavy phase exists in vacuum tank **100** up to heavy phase sump weir static level **172**. Vacuum sensor **420**, light phase receptacle liquid surface level sensor **720A**, light phase sump upper liquid surface level sensor **157A**, and heavy phase sump middle liquid surface level sensor **175A** controls vacuum pump **400** through electrical/logic panel **50**. Vacuum pump **400** runs whenever the vacuum intensity in vacuum tank **100** is less than the vacuum intensity control setting of vacuum sensor **420**, provided also that the liquid surface level free surface in light phase receptacle(s) **700** is below light phase receptacle liquid surface control level **720** as sensed by light phase receptacle liquid surface level sensor **720A**, and provided that the liquid free surface in light phase sump **150** is below light phase sump upper liquid surface control level **157** as sensed by light phase sump upper liquid surface level sensor **157A**. and provided that the liquid free surface in heavy phase sump **170** is below heavy phase sump middle liquid surface control level **175** as sensed by heavy phase sump middle liquid surface level sensor **175A**. Vacuum pump **400** does not run whenever the vacuum intensity in vacuum tank **100** matches, or is higher than, the vacuum intensity setting of vacuum sensor **420**, nor whenever the liquid free surface(s) in light phase receptacle(s) **700** is at, or above, light phase receptacle liquid surface control level **720** as sensed by light phase receptacle liquid surface level sensor **720A**, nor whenever the liquid free surface in light phase sump **150** is at, or above, light phase sump upper liquid surface control level **157** as sensed by light.phase sump upper liquid surface level sensor **157A**, nor whenever the liquid free surface in heavy phase sump **170** is at, above, heavy phase sump middle liquid surface control level **175** as sensed by heavy phase sump middle liquid surface level sensor **175A**. When running, vacuum pump **400** causes the vacuum intensity in vacuum tank **100** to increase by evacuating the air above any liquid free surfaces in vacuum tank **100** from vacuum tank **100** through vacuum pump inlet air conduit **430**, self-closing check valve **440**, and vacuum pump exhaust air conduit **431** into air vent conduit **730** and out air vent conduit cap **760**. Any vapors in the exhaust air of vacuum pump **400** that condense in vacuum pump exhaust air conduit **431** will flow to air vent conduit **730** and drain via air vent conduit **730** into light phase receptacle(s) **700**. When vacuum pump **400** is not running, the vacuum intensity in vacuum tank **100** tends to pull air back through air vent conduit cap **760**, vacuum pump exhaust air conduit **431**, vacuum pump **400**, and vacuum pump inlet air conduit **430**. However, self-closing check valve **440** seals the vacuum intensity in vacuum tank **100** by preventing reverse air flow in vacuum pump inlet air conduit **430**. In the preferred embodiment, self-closing check valve **440** is a spring loaded pneumatic check valve matched to accommodate the dynamic air flow characteristics of vacuum pump

400. Self-closing check valve **440** could also be a solenoid valve which opens when vacuum pump **400** runs and closes when vacuum pump **400** stops. If for some reason electric power fails to Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**, and if the vacuum intensity in vacuum tank **100** is lost completely before electric power is restored, positive air pressure inside vacuum tank **100** could build, which would violate codes and possibly cause a rupture or explosion of vacuum tank **100**, which could cause personnel injury and/or property damage. Self-closing relief check valve **441**, while sealing the vacuum in vacuum tank **100** during the normal operating conditions described above, provides automatic pressure relief directly to the atmosphere through bi-directional air conduit **432**, which connects to vacuum pump exhaust air conduit **431** (that is, without passing through self-closing check valve **440** or vacuum pump **400**) should a positive pressure develop in vacuum tank **100**. In the preferred embodiment, self-closing relief check valve **441** is a self-closing pneumatic check valve with a very low cracking pressure, say less than 0.5 psig. Self-closing relief check valve **441** could also be a solenoid valve which opens automatically whenever power to Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** fails, or whenever the vacuum intensity in vacuum tank **100** falls below 0 inches Mercury.

Vacuum regulating valve **443** is set to automatically admit atmospheric air whenever the vacuum intensity in vacuum tank **100** is slightly above the vacuum intensity control point or the upper limit of the vacuum intensity control range of vacuum sensor **420**, by say about 2 inches Mercury. Vacuum regulating valve **443** serves three purposes: (1) to ensure that the vacuum intensity in vacuum tank **100** does not appreciably exceed the control setting of vacuum sensor **420**, which would, under some mixed liquid collection circumstances where the vertical liquid lift height is relatively low, (say less than 8 feet) and the size of mixed immiscible liquids collection conduit(s) **230** is relatively large (say over 3 inches in diameter), transport the mixed immiscible liquids too fast, which could agitate and emulsify the mixed immiscible liquids unnecessarily; (2) helps ensure that the net positive suction head available at light phase extraction and discharge pump **500** and at heavy phase extraction and discharge pump **600** does not exceed the net positive suction head required by light phase extraction and discharge pump **500** and heavy phase extraction and discharge pump **600**; and (3) provides a source of air to vacuum pump **400** to prevent overheating and damage of vacuum pump **400** if vacuum pump **400** runs while not under the control of vacuum sensor **420**.

Solenoid relief valve **442** is closed whenever the liquid free surface in heavy phase sump **170** is below heavy phase sump upper liquid surface control level **176** as sensed by heavy phase sump upper liquid surface level sensor **176A**. Solenoid relief valve **442** is open whenever the liquid free surface in heavy phase sump **170** is at, above, heavy phase sump upper liquid surface control level **176** as sensed by heavy phase sump upper liquid surface level sensor **176A**. When open, solenoid relief valve **442** purges any vacuum in vacuum tank **100**, thereby preventing the overfilling of heavy phase sump **170**, which could occur if the flow rate through prefilter vessel exit conduit **231** appreciably exceeds the flow rate through heavy phase discharge conduit **41**. If the liquid free surface in heavy phase sump **170** is above light phase sump weir static level **154**, then heavy phase liquid will inadvertently spill over light phase sump left plate **151** into light phase sump **150**, thereby re-mixing heavy phase liquid with light phase liquid, which subverts the main function of the invention.

Vacuum/pressure gauge **450** provides a visual measurement of the vacuum intensity in vacuum tank **100**.

Mixed immiscible liquids, plus any grit, sediment, particulates, and floating debris, and plus any entrained air flow through mixed immiscible liquids collection conduit(s) **230** and collection network valve **243** into prefilter vessel **200** due to the vacuum in vacuum tank **100**. When local collection valve **244** is open, a proximate source of mixed immiscible liquids, plus any grit, sediment, particulates, and floating debris, and plus any entrained air can also flow through local collection conduit **232** and local collection valve **244** into prefilter vessel **200** due to the vacuum in vacuum tank **100**. Any grit, sediment, and/or particulates that enters prefilter vessel **200** whose specific gravity is greater than the specific gravity of the heavy phase in the mixed immiscible liquids will descend to the bottom of prefilter vessel **200**, where prefilter element **202** will prevent their migration into prefilter vessel exit conduit **231**. Prefilter element **202** will also prevent the migration of any floating debris into prefilter vessel exit conduit **231**. Mixed immiscible liquids will pass through prefilter element **202** into prefilter vessel exit conduit **231** due to the vacuum in vacuum tank **100**. As the openings in prefilter element **202** plug with grit, sediment, particulates, and/or floating debris, the liquid free surface in prefilter vessel **200** will gradually ascend. Once the liquid free surface ascends to, or past, prefilter vessel high liquid surface control level **210**, prefilter vessel high liquid surface level sensor **210A** will sense the liquid free surface, and will simultaneously initiate a visual and/or audible alarm in electrical/logic panel **50** that alerts the operator to replace prefilter element **202**, and/or other Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** functions as selected through electrical/logic panel **50**. Vacuum/pressure gauge **250** provides a visual measurement of the vacuum intensity in prefilter vessel **200**. Removable prefilter vessel cover **201** is provided for prefilter vessel **200** to permit access to prefilter element **202** for maintenance or replacement.

Upon exiting prefilter vessel **200**, mixed immiscible liquids and any entrained air flow through prefilter vessel exit conduit **231** and prefilter vessel exit flow control valve **245** into energy dissipation and flow distribution chamber **110**. In practical operation, prefilter vessel exit flow control valve **245** is sized, or is partially closed, to limit the actual maximum inflow rate into vacuum tank **100** to the design inflow rate in vacuum tank **100** under probable worst case conditions (i.e., a relatively high vacuum in vacuum tank **100** combined with a relatively low vertical liquid lift distance from the highest remote source of mixed immiscible liquids with respect to the top of prefilter vessel **200**).

Mixed immiscible liquids and any entrained air in energy dissipation and flow distribution chamber **110** then descend through energy dissipation and flow distribution chamber perforated bottom plate **113** due to the vacuum in vacuum tank **100**. The mixed immiscible liquids that exit energy dissipation and flow distribution chamber **110** descend to, and collect on the top of, separated light phase protection roof **114**. Because separated light phase protection roof right end plate **115** presents a barrier to rightward flow into main gross phase separation chamber **140**, mixed immiscible liquids flow leftward over the left edge of separated light phase protection roof **114** into separated light phase anti-disturbance chamber **130**. Any entrained air separates from any mixed immiscible liquids and flows rightward above any mixed immiscible liquids that exist on top of separated light phase protection roof **114**, then over separated light phase protection roof right end plate **115**, and then to the penetration of vacuum pump inlet air conduit **430** into air void **120**.

Mixed immiscible liquids flow into separated light phase anti-disturbance chamber **130** is relatively calm and nonturbulent to minimize agitation of any floating light phase that might exist in separated light phase anti-disturbance chamber **130**. Any heavy phase in the mixed immiscible liquids that enters separated light phase anti-disturbance chamber **130** will descend through any floating light phase that

might exist in separated light phase anti-disturbance chamber **130** into main gross phase separation chamber **140**. Downward heavy phase flow friction in separated light phase anti-disturbance chamber **130** might also drag into main gross phase separation chamber **140** some of the floating light phase that might exist in separated light phase anti-disturbance chamber **130**. Any light phase in the mixed immiscible liquids that enters separated light phase anti-disturbance chamber **130** will displace downward any floating light phase that might exist in separated light phase anti-disturbance chamber **130** into main gross phase separation chamber **140**.

Any heavy phase that enters main gross phase separation chamber **140** will displace the existing heavy phase in main gross phase separation chamber **140** into heavy phase equalization chamber **160** to heavy phase sump weir dynamic level **173** and over heavy phase sump left plate **171** into heavy phase sump **170**. Any heavy phase that enters main gross phase separation chamber **140** will also displace upward any floating accumulated light phase in main gross phase separation chamber **140**. Depending on the flow rate of the heavy phase over the top of heavy phase sump left plate **171**, the specific gravity of any floating accumulated light phase in main gross phase separation chamber **140**, and the vertical distance between light phase sump weir static level **154** and the liquid free surface of any floating accumulated light phase in main gross phase separation chamber **140**, floating accumulated light phase will ascend to light phase sump weir dynamic level **155** and will flow over the top of light phase sump left plate **151** into light phase sump **150**.

Any discrete light phase that enters main gross phase separation chamber **140**, or any mixed, dispersed, or emulsified light phase that separates from the heavy phase in main gross phase separation chamber **140**, will ascend in main gross phase separation chamber **140** and will form, or join, a layer of floating accumulated light phase above light phase/heavy phase interface **144**. Any light phase that enters into main gross phase separation chamber **140** will also displace existing heavy phase in main gross phase separation chamber **140** into heavy phase equalization chamber **160** to heavy phase sump weir dynamic level **173** and over heavy phase sump left plate **171** into heavy phase sump **170**. Once the floating accumulated light phase in main gross phase separation chamber **140** attains a depth equal to the following calculated number:

$$D_{LP} = [\ (W_{LP,\ STATIC}) - (W_{HP,\ DYNAMIC})\ ] / [1 - (SG_{LP} / SG_{HP})\ ]$$

Where: D_{LP} = Depth of floating light phase to light phase/heavy phase interface **144**, measured in inches

$W_{LP,\ STATIC}$ = Weir elevation, light phase, static, measured in inches, also light phase sump weir static level **154**

$W_{HP,\ DYNAMIC}$ = Weir elevation, heavy phase, dynamic, measured in inches, also heavy phase sump weir dynamic level **173**

SG_{LP} = Specific Gravity, light phase

SG_{HP} = Specific Gravity, heavy phase

continued additional light phase entering into, or separating in, main gross phase separation chamber **140**, will cause the liquid free surface of floating accumulated light phase light phase to ascend above light phase sump weir static level **154** and to flow over light phase sump left plate **151** into light phase sump **150**. Also while light phase enters into, or separates in, main gross phase separation chamber **140**, heavy phase will continue to flow over heavy phase sump left plate **171** into heavy phase sump **170**

until the depth of the floating light phase in main gross phase separation chamber **140** attains the following calculated number:

$$D_{LP} = [\ (W_{LP,\ DYNAMIC}) - (W_{HP,\ STATIC})\ ]\ /\ [1 - (SG_{LP}\ /\ SG_{HP})\ ]$$

Where: D_{LP} =	Depth of floating light phase to light phase/heavy phase interface **144**, measured in inches
$W_{LP,\ DYNAMIC}$ =	Weir elevation, light phase, dynamic, measured in inches, also light phase sump weir dynamic level **155**
$W_{HP,\ STATIC}$ =	Weir elevation, heavy phase, static, measured in inches, also heavy phase sump weir static level **172**
SG_{LP} =	Specific Gravity, light phase
SG_{HP} =	Specific Gravity, heavy phase

Once in main gross phase separation chamber **140**, mixed immiscible liquid phase separation begins automatically by, as a minimum, differential specific gravity dissociation and vacuum induced low grade dissolved air floatation. Heavy phase flows from separated light phase anti-disturbance chamber **130** rightward and downward through main gross phase separation chamber **140** towards the entrance to heavy phase equalization chamber **160**. Heavy phase flows through oleophilic media **143**, if installed (recommended if the heavy phase is water or seawater and the light phase is oil). Oleophilic media **143** is selected to attract any light phase liquids or droplets dispersed in the heavy phase while simultaneously repelling the heavy phase. Oleophilic media **143** is also selected to be continuously self-cleaning. During heavy phase descent through oleophilic media **143**, any dispersed light phase droplets that have not already separated from the heavy phase and risen and joined any light phase floating on top of the heavy phase contact the surfaces of oleophilic media **143**, which attracts these dispersed light phase droplets. On the surface of oleophilic media **143**, these dispersed light phase droplets can coalesce into larger ones, which eventually grow large enough to separate from the surface of oleophilic media **143** and rise through the heavy phase at a velocity faster than the net effective downward velocity (plug flow) of the heavy phase. Any rising light phase droplets originating from relatively deep in the oleophilic media **143** bed typically impinge on other oleophilic media **143** surfaces, causing them to attach again, grow again, separate again, and rise again. This attachment, separation, detachment, and ascent cycle continues until rising droplets no longer encounter any oleophilic media **143** during their ascent. In the meantime, the heavy phase liquid contains lesser and lesser dispersed light phase droplets as it passes through oleophilic media **143**.

Light phase sump upper liquid surface level sensor **157A** and light phase sump lower liquid surface level sensor **156A** control the operation of light phase extraction and discharge pump **500**. Light phase extraction and discharge pump **500** will not run if the liquid free surface in light phase sump **150** is at, or below, light phase sump lower liquid surface control level **156** as sensed by light phase sump lower liquid surface level sensor **156A**. If the liquid free surface in light phase sump **150** is above light phase sump lower liquid surface control level **156**, then light phase extraction and discharge pump **500** will run if the control selector switch (not shown) for light phase extraction and discharge pump **500** on electrical/logic panel **50** is in the "manual" position. If the control selector switch (not shown) for light phase extraction and discharge pump **500** on electrical/logic panel **50** is in the "automatic" position, then light phase extraction and discharge pump **500** will start and run if the liquid free surface in light phase sump **150** is at light phase sump upper liquid surface control level **157** as sensed by light phase sump upper liquid

surface level sensor **157A**. Once started by light phase sump upper liquid surface level sensor **157A**, light phase extraction and discharge pump **500** will continue to run (unless a power failure occurs, or unless an operator shifts the control selector switch to the "off" or "manual" position) until the liquid free surface in light phase sump **150** descends to light phase sump lower liquid surface control level **156** as sensed by light phase sump lower liquid surface level sensor **156A**.

Heavy phase sump lower liquid surface level sensor **174A** and heavy phase sump middle liquid surface level sensor **175A** control the operation of heavy phase extraction and discharge pump **600**. Heavy phase extraction and discharge pump **600** will not run if the liquid free surface in heavy phase sump **170** is at, or below, heavy phase sump lower liquid surface control level **174** as sensed by heavy phase sump lower liquid surface level sensor **174A**. If the liquid free surface in heavy phase sump **170** is above heavy phase sump lower liquid surface control level **174**, then heavy phase extraction and discharge pump **600** will run if the control selector switch (not shown) for heavy phase extraction and discharge pump **600** on electrical/logic panel **50** is in the "manual" position. If the control selector switch (not shown) for heavy phase extraction and discharge pump **600** on electrical/logic panel **50** is in the "automatic" position, then heavy phase extraction and discharge pump **600** will start and run if the liquid free surface in heavy phase sump **170** is at heavy phase sump middle liquid surface control level **175** as sensed by heavy phase sump middle liquid surface level sensor **175A**. Once started by heavy phase sump middle liquid surface level sensor **175A**, heavy phase extraction and discharge pump **600** will continue to run (unless a power failure occurs, or unless an operator shifts the control selector switch to the "off" or "manual" position) until the liquid free surface in heavy phase sump **170** descends to heavy phase sump lower liquid surface control level **174** as sensed by heavy phase sump lower liquid surface level sensor **174A**.

Vacuum pump **400**, light phase extraction and discharge pump **500**, and heavy phase extraction and discharge pump **600** can all run simultaneously.

Once exiting oleophilic media **143**, the heavy phase liquid, now free of much of the finely dispersed light phase droplets, enters heavy phase equalization chamber **160**. The heavy phase flows rightward under light phase sump bottom plate **152**, ascends between light phase sump right plate **153** and heavy phase sump left plate **171** to heavy phase sump weir dynamic level **173**, and flows over the top of heavy phase sump left plate **171** into heavy phase sump **170**.

Heavy phase extraction and discharge pump **600**, when running, pulls heavy phase through heavy phase extraction and discharge pump suction conduit **630**, heavy phase extraction and discharge pump suction shut-off valve **642**, and check valve **641**. Check valve **641** prevents heavy phase backflow and/or air leakage into heavy phase sump **170** through heavy phase extraction and discharge pump suction conduit **630** when heavy phase extraction and discharge pump **600** is off, which would otherwise occur due to the constant vacuum in vacuum tank **100**. In the preferred embodiment, check valve **641** is a vertically oriented ball check valve. Check valve **641** could also be a normally closed solenoid or motorized valve which opens whenever heavy phase extraction and discharge pump **600** starts and runs, and closes whenever heavy phase extraction and discharge pump **600** stops. Check valve **641** could also be another type of check valve, such as a self-closing model, where its satisfactory operation is not dependent on its physical orientation.

Light phase extraction and discharge pump **500**, when running, pulls light phase through light phase extraction and discharge pump suction conduit **530**, light phase extraction and discharge pump suction shut-off valve **542**, and check valve **541**. Check valve **541** prevents light phase backflow and/or air leakage into light phase sump **150** through light phase extraction and discharge pump suction conduit **530** when light phase extraction and discharge pump **500** is off, which would otherwise occur due to the constant vacuum in vacuum tank **100**. In the preferred embodiment, check valve **541** is a vertically oriented ball check valve. Check valve **541** could also be a normally closed solenoid or motorized valve which opens whenever light phase extraction and discharge pump **500** starts and runs, and closes whenever light phase extraction and discharge pump **500** stops. Check valve **541** could also be another type of check valve, such as a self-closing model, where its satisfactory operation is not dependent on its physical orientation. Siphon breaker **545** prevents the inadvertent siphonage of the contents of light phase sump **150** through light phase extraction and discharge pump suction conduit **530** through light phase extraction and discharge pump suction shut-off valve **542** through check valve **541** through light phase extraction and discharge pump **500** through partially treated light phase conduit **32** into light phase receptacle(s) **700** if, for example, light phase extraction and discharge pump **500** were running at the time of a total power failure to Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** and vacuum tank **100** was not under vacuum and was open to the atmosphere.

Heavy phase extraction and discharge pump **600** discharges heavy phase liquids through partially treated heavy phase conduit **42** through heavy phase extraction and discharge pump discharge shut-off valve **643** into heavy phase intermediate separation stage **40**. In the preferred embodiment, heavy phase extraction and discharge pump **600** is a positive displacement, low shear, pump. In this embodiment, pressure relief valve **640** limits the discharge pressure of heavy phase extraction and discharge pump **600**, which protects heavy phase extraction and discharge pump **600**, heavy phase intermediate separation stage **40**, and all associated piping, tubing, and other connected devices. If the pressure at the discharge of heavy phase extraction and discharge pump **600** exceeds the control setting of pressure relief valve **640,** the valve in pressure relief valve **640** opens, allowing liquid to return to the inlet of heavy phase extraction and discharge pump **600**.

Light phase extraction and discharge pump **500** discharges light phase liquids through partially treated light phase conduit **32** into light phase receptacle(s) **700**. In the preferred embodiment, light phase extraction and discharge pump **500** is a positive displacement, low shear, pump. In this embodiment, pressure relief valve **540** limits the discharge pressure of light phase extraction and discharge pump **500**, which protects light phase extraction and discharge pump **500** and all associated piping, tubing, and other connected devices. If the pressure at the discharge of light phase extraction and discharge pump **500** exceeds the control setting of pressure relief valve **540,** the valve in pressure relief valve **540** opens, allowing liquid to return to the inlet of light phase extraction and discharge pump **500**. Vacuum/pressure gauge **550** provides a visual measurement of the discharge pressure of light phase extraction and discharge pump **500**.

In heavy phase intermediate separation stage **40**, heavy phase liquids enter through partially treated heavy phase conduit **42** into coalescer vessel **300**, which holds coalescer element **302**. Coalescer element **302** is selected to dynamically separate very finely dispersed, or emulsified, light phase droplets from the heavy phase carrier. In the preferred embodiment where the heavy phase liquid is water or seawater and the light phase liquid is lubricating, fuel, or vegetable oil, coalescer element **302** is a coalescer filter element made by any one of a number of manufacturers, such as FACET, SAREX,

VELCON, SERFILCO, or BANNER ENGINEERING. Coalescer element **302** could also be one of many other devices which can separate the mixed immiscible liquids, such as an ultrafiltration membrane. In the preferred embodiment, liquid entering coalescer vessel **300** flows through coalescer element **302** from the interior of coalescer element **302** to the exterior of coalescer element **302**. While passing through coalescer element **302**, finely dispersed light phase droplets coalesce, grow, and form large droplets on the outside surface of coalescer element **302**, which eventually separate from coalescer element **302** and ascend to the top of coalescer vessel **300**, where heavy phase intermediate separation stage light phase return conduit **43** carries both phases through metering valve **343** and self-closing quick disconnect **344** into energy dissipation and flow distribution chamber **110**, whereupon they reenter main gross phase separation chamber **140** as described above, separate again, and finally rejoin their respective phases in main gross phase separation chamber **140**. Metering valve **343** adjusts to prevent turbulent flow in heavy phase intermediate separation stage light phase return conduit **43** without causing accumulation of separated light phase liquid at the top of coalescer vessel **300**. Removable coalescer vessel cover **301** is provided for coalescer vessel **300** to permit access to coalescer element **302** for maintenance or replacement.

Heavy phase passing through coalescer element **302** flows out the bottom of coalescer vessel **300** into heavy phase discharge conduit **41**, through shut-off valve **341**, through check valve **342**, and then through siphon breaker **345** to the heavy phase terminal facility. Check valve **342** prevents heavy phase backflow and air leakage into vacuum tank **100** through heavy phase discharge conduit **41**, shut-off valve **341**, coalescer vessel **300**, and heavy phase intermediate separation stage light phase return conduit **43**, which would otherwise occur due to the constant vacuum in vacuum tank **100**. In the preferred embodiment, check valve **342** is a vertically oriented ball check valve. Check valve **342** could also be a normally closed solenoid or motorized valve which opens whenever heavy phase extraction and discharge pump **600** starts and runs, and closes whenever heavy phase extraction and discharge pump **600** stops. Check valve **342** could also be another type of check valve, such as a self-closing model, where its satisfactory operation is not dependent on its physical orientation. Siphon breaker **345** prevents the inadvertent siphonage of the contents of heavy phase sump **170** through heavy phase extraction and discharge pump suction conduit **630** through heavy phase extraction and discharge pump suction shut-off valve **642** through check valve **641** through heavy phase extraction and discharge pump **600** through partially treated heavy phase conduit **42** through heavy phase intermediate separation stage **40** through shut-off valve **341** through check valve **342** to the heavy phase terminal facility if, for example, heavy phase extraction and discharge pump **600** were running at the time of a total power failure to Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** and vacuum tank **100** was not under vacuum and was open to the atmosphere.

Through taps into coalescer vessel **300** and into partially treated heavy phase conduit **42** upstream of heavy phase extraction and discharge pump discharge shut-off valve **643**, differential pressure sensor **320** senses the differential pressure entering and exiting heavy phase intermediate separation stage **40**. Differential pressure sensor **320** controls visual and/or audible alarms (not shown), and/or other Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** functions as selected through electrical/logic panel **50**. In the preferred embodiment, whenever the differential pressure matches or exceeds the control setting of differential pressure sensor **320**, say by about 15 pounds per square inch gauge, electrical/logic panel **50** connects and maintains power to remote and/or local visual and audible alarms to alert personnel that coalescer element **302** is probably fouled or plugged, and therefore requires replacement to preserve design throughput flow. Vacuum/pressure

gauge **350** and vacuum/pressure gauge **650** tapped into coalescer vessel **300** and partially treated heavy phase conduit **42**, respectively, measure the respective inlet and outlet pressures of heavy phase intermediate separation stage **40**. A single differential pressure gauge, or a compound readout pressure gauge could also be used to provide an alternate means to ascertain the differential pressure.

Drain valve **340** is opened to vacuum-drain the contents of coalescer vessel **300** into energy dissipation and flow distribution chamber **110** through drain conduit **330** whenever servicing of coalescer vessel **300** or coalescer element **302** is required. Flow rate limiting orifice **303** limits the flow exiting coalescer vessel **300** into energy dissipation and flow distribution chamber **110**. In the preferred embodiment, drain valve **340** is a manually operated single union or true union ball valve. Other types of valves can also be used. One procedure to drain coalescer vessel **300** follows. Run heavy phase extraction and discharge pump **600** manually until heavy phase sump lower liquid surface level sensor **174A** interrupts heavy phase extraction and discharge pump **600**. Place heavy phase extraction and discharge pump **600** selector switch on electrical/logic panel **50** in "off" position. Open drain valve **340**. Open metering valve **343**. Disconnect self-closing quick disconnect **344**. The vacuum in vacuum tank **100** will pull the liquid from coalescer vessel **300** through drain conduit **330** into energy dissipation and flow distribution chamber **110**. As liquid exits coalescer vessel **300**, atmospheric air will enter coalescer vessel **300** through metering valve **343** to replace the volume of liquid removed. Close drain valve **340** when coalescer vessel **300** is empty or sooner. Other coalescer vessel **300** drainage procedures using optional additional devices, such as purge valves installed in removable coalescer vessel cover **301**, are possible.

Referring momentarily to FIG 2, in the preferred embodiment, and where the heavy phase liquid is water or seawater and the light phase is lubricating oil, fuel oil, or vegetable oil, light phase intermediate separation stage **30** and light phase intermediate separation stage heavy phase return conduit **33** are not provided. Instead, the light phase flows directly through partially treated light phase conduit **32** and light phase discharge conduit **31** into its respective terminal facility.

Referring again to FIG 3, in the preferred embodiment, and where the heavy phase liquid is water or seawater and the light phase is lubricating oil, fuel oil, or vegetable oil, the final destination (i.e., terminal facility) for light phase flow in partially treated light phase conduit **32** past siphon breaker **545** is light phase receptacle(s) **700**. Light phase receptacle(s) **700** can be one or many containers, receptacles, tanks, or barrels. As light phase receptacle(s) **700** fill(s), the liquid level(s) rise(s), displacing air inside through air vent conduit(s) **730** and out air vent conduit cap(s) **760** into the atmosphere. Whenever the free surface liquid level in light phase receptacle(s) **700** is at, or above, light phase receptacle liquid surface control level(s) **720**, light phase receptacle liquid surface level sensor(s) **720A** will, through electrical/logic panel **50**, energize remote and/or local audible and/or visual alarms, while simultaneously electrically disabling vacuum pump **400**, light phase extraction and discharge pump **500**, and heavy phase extraction and discharge pump **600**, and all their respective control circuits, thereby preventing the overfilling of light phase receptacle(s) **700** by Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10**. Local alarms located at light phase receptacle(s) **700** can serve to alert anyone in the vicinity that light phase receptacle(s) **700** are nearly full, which should dissuade anyone from manually introducing additional liquid into light phase receptacle(s) **700**

Drain valve **145** provides for the drainage of main gross phase separation chamber **140** and of heavy phase equalization chamber **160**. Drain valve **159** provides for the drainage of light phase sump **150**. Drain valve **178** provides for the drainage of heavy phase sump **170**.

Referring to FIG 3, FIG 4, and FIG 5, in the preferred embodiment, element replacement in prefilter vessel **200** can occur as follows: Have a bucket or other portable container available; place vacuum pump **400** selector switch on electrical/logic panel **50** in "off" position; open local collection valve **244** to purge vacuum in prefilter vessel **200** and in vacuum tank **100**; when vacuum purged from vacuum tank **100**, close prefilter vessel exit flow control valve **245**, collection network valve **243**, and local collection valve **244**; temporarily disconnect mixed immiscible liquids collection conduit **230** from removable prefilter vessel cover **201**; remove removable prefilter vessel cover **201**; temporarily disconnect prefilter vessel exit flow control valve **245** from segment of prefilter vessel exit conduit **231** between prefilter vessel exit flow control valve **245** and prefilter vessel outlet vacuum tank penetration **116**; unhook latches; tilt prefilter vessel **200** forward with the bucket placed under the top leading edge (to catch any floating debris and residual liquid in prefilter vessel **200**) until the restraining chain or wire restraint prevents further tilting of prefilter vessel **200**; remove prefilter element **202**; remove grit, sediment, and particulates from prefilter vessel **200**.

Referring to FIG 3, FIG 4, and FIG 5, in the preferred embodiment, element replacement in coalescer vessel **300** can occur as follows: Drain coalescer vessel **300** as described above; close drain valve **340**; temporarily disconnect partially treated heavy phase conduit **42** from removable coalescer vessel cover **301**; temporarily disconnect siphon breaker **345** from the heavy phase terminal facility; temporarily disconnect drain valve **340** from segment of drain conduit **330** between drain valve **340** and coalescer vessel drain vacuum tank penetration **117**; unhook latches; tilt coalescer vessel **300** forward until the restraining chain or wire prevents further tilting of coalescer vessel **300**; remove removable coalescer vessel cover **301**; unmount coalescer element **302** from removable coalescer vessel cover **301**.

In the presently preferred embodiment, the following parts, materials, and components are used:

100	24" diameter, SDR 41, Type I PVC, 62" long, with welded, reinforced/braced 1" thick PVC ends, 72" overall length
143	JAEGAR PRODUCTS 1" diameter TRI-PAC
156A, 157A	THOMAS PRODUCTS custom float switch 4500-46572
174A, 175A, 176A	THOMAS PRODUCTS custom float switch 4500-46573
201	VELCON FILTERS, INC FO-614PLF5 filter cartridge
202	BANNER ENGINEERING CORPORATION OWS 14603 coalescer cartridge, 5 micron rating
210A	THOMAS PRODUCTS 4500-41122 float switch
243, 245, 145,	COLONIAL ENGINEERING V10141B single union PVC ball valve, 1"

159, 178, 542, 642	
320	BARKSDALE EPD1H-BB40 differential pressure switch
340, 341, 543, 643	COLONIAL ENGINEERING V08141B single union PVC ball valve, 3/4"
342	COLONIAL ENGINEERING V08232B single union PVC ball check valve, 3/4"
345, 545	CASH ACME V101-3/4 siphon breaker valve
400	GAST MANUFACTURING CORPORATION 1023-101Q-G608X vacuum pump
420	BARKSDALE 96221-BB1-T5-W36 vacuum switch
440	SMC 490-6M6M-B air check valve
441	SMC 490-6M6M-B air check valve (w/ spring removed)
442	ASCO J8210G93 240V/60Hz solenoid valve
443	CASH ACME FRM-V-3/8 vacuum relief valve
500, 600	CONTINENTAL PUMP COMPANY CPM33-CSQMT-1/2-1-4 progressing cavity pump
541, 641	COLONIAL ENGINEERING V10232B single union PVC ball check valve, 1"
540, 640	CASH ACME MC75 pressure relief valve

Conclusion, Ramifications, and Scope of Invention.

Thus the reader will see that the invention significantly improves the previously patented Mixed Immiscible Liquids Collection, Separation, and Disposal Method and System (US Pat 5,679,258 issued to Petersen 1997 October 21).

While the above description contains many specificities, they should not be construed as limitations on the scope of the invention, but rather as an exemplification of one preferred embodiment thereof. Besides those already mentioned, many other variations are possible. For example, referring to FIG 2, heavy phase intermediate separation stage **40** and heavy phase intermediate separation stage light phase return conduit **43** could be eliminated if the heavy phase separation occurring in vacuum tank **100** satisfied the heavy phase terminal facility receiving requirements. Thus Mixed Immiscible Liquids Vacuum, Separation, and Disposal Method and System (Mod 1) **10** could discharge the separated heavy phase from vacuum tank **100** directly through partially treated heavy phase conduit **42** and heavy phase discharge conduit **41** to, say, heavy phase reuse elsewhere. Also, referring to FIG 3, light phase sump lower liquid surface level sensor **156A**, light phase sump upper liquid surface level sensor **157A**, heavy

phase sump lower liquid surface level sensor **174A**, heavy phase sump middle liquid surface level sensor **175A**, and heavy phase sump upper liquid surface level sensor **176A** could satisfactorily perform their stated functions if each was mounted separately through the side of vacuum tank **100** instead of together on the same guide rod. Also, referring to FIG 3, a normally closed float operated valve inside vacuum tank **100** that opens to the atmosphere when the liquid level in heavy phase sump **170** is at, or above, heavy phase sump upper liquid surface control level **176** could substitute for the vacuum tank **100** vacuum purging function that solenoid relief valve **442** performs in concert with heavy phase sump upper liquid surface level sensor **176A**. Also, referring to FIG 3, coalescer element **302** could mount to the bottom of coalescer vessel **300** instead of removable coalescer vessel cover **301**, with partially treated heavy phase conduit **42** penetrating the bottom of coalescer vessel **300** instead of removable coalescer vessel cover **301**. Coalescer vessel **300** can also orient horizontally, provided that partially treated heavy phase conduit **42** continues to deliver liquid flow to the interior of coalescer element **302**, and provided that heavy phase intermediate separation stage light phase return conduit **43** connects at the top of coalescer vessel **300**, and provided that heavy phase discharge conduit **41** connects to the bottom of coalescer vessel **300** at the opposite end where partially treated heavy phase conduit **42** penetrates into coalescer vessel **300**.

Accordingly, the scope of the invention should be determined not by the embodiment(s) illustrated, but by the appended claims and their legal equivalents.